



Review of the Book «Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures»



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Sapozhnikov, VI. V. Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures. Moscow, Nauka publ., 2021, 229 p. ISBN 978-5-02-040877-7.

The article provides a short review of the just published book by Professor VI. V. Sapozhnikov entitled «Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures».

The book covers the basics of the synthesis of safety train traffic control systems at railway stations. Control systems at the stage of abstract synthesis are represented in the form of a

set of multitudes of finite state machines, the implementation of which excludes the conditions for occurrence of dangerous failures and, accordingly, for occurrence of catastrophic disruptions in work, causing threats to passengers and transported goods.

The book is recommended to developers of systems of control of responsible technological processes, computer-aided design systems, testing, technical diagnostics and monitoring of automation devices in transport and industry, as well as to the students, Ph.D. students, academia, specialists in the field of synthesis of control systems.

Keywords: train traffic control, railway stations, failures, synthesis of control systems.

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*The text of the review article originally written in Russian is published in the first part of the issue.
Текст статьи-рецензии на русском языке публикуется в первой части данного выпуска.*

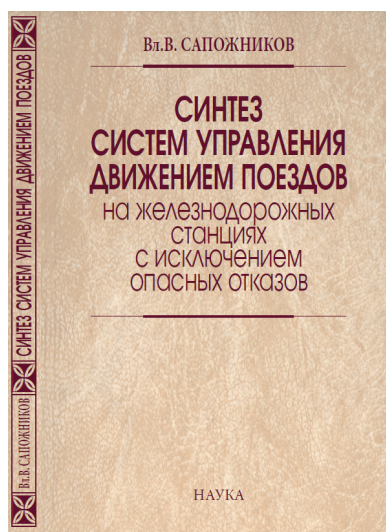
A large number of works devoted to the problems of building safety control systems in transport and in industry have been published since the inception of methods for their synthesis, both on a relay and on a microelectronic and microprocessor basis up to the present time. Technologies and element base are constantly being improved, moving forward in conformity with scientific and technological progress. Both the components and the methods of implementation of devices based on them are changing, their dimensions are decreasing, the thresholds of the elements are diminishing, etc. Those large devices that half a century ago performed the simplest operations of turning on or off control objects are being replaced by devices that are sometimes difficult to be distinguished with the naked eye. Humanity is moving from implementation of low-functional devices to multifunctional ones, capable of being placed in a space of minimal volume. The effect of progress should be emphasized in the field of, for example, microelectronics: movement of trains at a railway station may well be controlled by a modern smartphone instead of a whole installation of electrical interlocking. Another question, of course, is provision of reliable and safe execution of control algorithms using miniature technology!

In the autumn of 2021, a book, unique in its content, was published, written by our compatriot and a prominent scientist in the field of railway automation and remote control. Honored Scientist of the Russian Federation, D.Sc. (Eng), Professor Vladimir Vladimirovich Sapozhnikov (Pic. 1), who made a colossal contribution to development of methods for the synthesis of reliable and safe control systems in transport industry. The book was entitled «Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures» (Pic. 2) and covered the fundamentals of abstract and structural synthesis of control systems at railway stations.

It should be noted that in a large number of countries, railway networks are fragmented into stations and hauls. At the stations, in contrast to the hauls, there is a track development, railway switches are installed, and all the main operations are performed with cars, locomotives, trains. That is why the most important issue is to organise traffic control at the station. On the haul, this process has by now been brought to automatism:



Pic. 1. Vladimir Vladimirovich Sapozhnikov (1940–2020), author of the book.



Pic. 2. Cover of the book «Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures».

traffic lights are actually switched by moving trains themselves. To regulate the movement of trains, shunting trains and locomotives at stations, the technical means of railway automation and remote control are used, which are enacted by the station attendants (in a number of systems, auto-action modes are provided). Control systems are implemented in such a way as to exclude both impact of human factor on safety of algorithm execution and the influence of external and internal destabilising factors. Thus, the task of implementing circuit solutions for reliable and safe implementation of control algorithms for automated objects at stations is



the most important. In the reviewed edition, attention is focused precisely on solving this problem.

In the book, the circuits of railway automation and remote control are presented in the form of single-cycle (combinational) and multi-cycle (with memory) finite state machines (FSMs). The scientific task of synthesising safety FSMs is stated, such automatic device should exclude false influences during operations, causing switching on of controlled objects and performance of functions that are not included in the algorithms. From a practical plane, the author transfers the solution of the problem into a theoretical one, due to the use of the algebra of regular events. And the dangerous transitions from state to state themselves are excluded at the stage of abstract synthesis of the FSM.

The most important provision (the theorem on safety automata) for the theory of synthesis of safety control systems in the form of finite automata is formulated: there are no dangerous failures in operation of a FSM if and only if for all false transitions $S_i \rightarrow S_f$ and for all false events k the condition is satisfied:

$$E_{S_i \rightarrow S_f} E_{f(k)} \cap E_{dan_k} = \emptyset,$$

where $E_{S_i \rightarrow S_f}$ – a set of words corresponding to false transitions of FSM from state S_i to state S_f ;

$E_{f(k)}$ – a set of words that transfer FSM from state S_f to the states representing false events from the set E_k ;

E_{dan_k} – a set of words that transfer the FSM into dangerous states.

The conditions introduced by the author based on regular expressions made it possible to formulate algorithms for the synthesis of FSM that exclude their transitions to dangerous states in case of any failures, the probability of which must be considered. To exclude dangerous failures in the FSM, it is sufficient to prohibit all dangerous false transitions.

The book is divided into four chapters, covering the following main topics:

1. Basics of synthesis of FSMs eliminating dangerous failures.
2. Basics of synthesis of circuits on a relay basis eliminating dangerous failures.
3. Basics of abstract synthesis of electrical centralised interlocking.
4. Basics of structural synthesis of electrical centralised interlocking.

For each chapter, the author offers brief conclusions that focus the reader's attention on the main provisions that determine the features of the analysis and synthesis of safety FSMs and circuits for electrical centralised interlocking of switches and signals.

It is noteworthy that the results described by the author in the book are not tied to a specific element base, and all considered implementations are in fact examples of synthesis of control circuits on a relay basis and on the simplest gates. The described theoretical foundations are not only relevant for the current stage of development of the transport industry but will also be in demand in the future. It is difficult even to cover the period during which this book will still «remain modern». Moreover, the theoretical foundations described in the book can be easily extended to other practical applications both in the transport sector and in the industry.

Based on practical experience, it should be noted that this publication will be useful to engineers and developers of safe control and monitoring systems. Using the materials of this book would help to solve a large number of questions. Currently, a number of engineers and developers are forced to repeat the path already taken by the author, although it is more correct to use the accumulated experience and enhance the results shown in the book.

The book of Professor V. V. Sapozhnikov «Synthesis of Systems of Train Traffic Control at Railway Stations Eliminating Dangerous Failures» is recommended for reading not only by engineers, developers, students, Ph.D. students and academic staff in the field of railway automation and remote control, but also by specialists in the field of synthesis of control systems in other railway, transport and industrial sectors. ●

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